Introduction to Accelerator Physics 2014

The CERN Accelerator School

CANDLE

The orbit and dispersion corrections for European XFEL SASE 1 undulator section

Nvard G. Ghazaryan *CANDLE SRI, Yerevan, Armenia*

Abstract

The results of the electron beam orbit correction in European XFEL SASE1 undulator section area presented taking into account the quadrupoles and Beam Position Monitors (BPM) random misalignments and the BPMs reading errors. The three correction algorithms, namely one-to-one correction, dispersion correction and the dispersion free steering are considered. The comparative analyses of the beam dynamics aspects are given. The corrections have been performed using ELEGANT and MATLAB codes.

INTRODUCTION

In the paper three algorithms of beam trajectory and dispersion correction for European "XFEL" SASE 1 undulator section are described. The correction scheme is based mainly on the SVD algorithm to solve the least square problem.

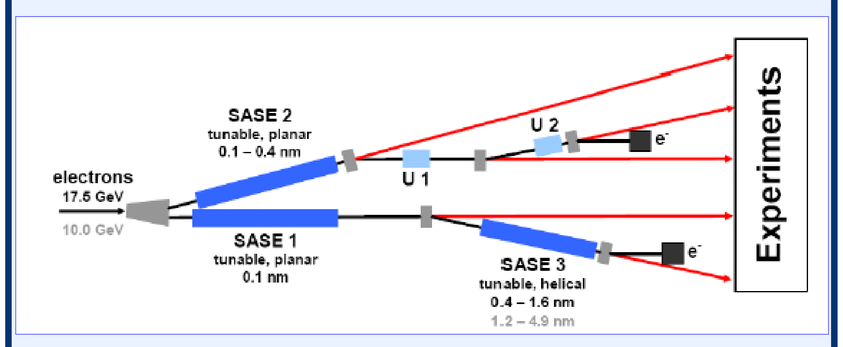


Figure 1: Schematic layout of European XFEL

Design energy	17.5Gev
SASE 1 length	201.3m
Undulator length	5m
FODO period length	12.2m
Number of FODO cells	17
Quad. length	0.1m
Quad. rms mis.	100μm
BPM rms mis.	100μm
BPM rms res. error	1μm

Table 1: XFEL SASE 1 undulator section specifications

ONE-TO-ONE CORRECTION

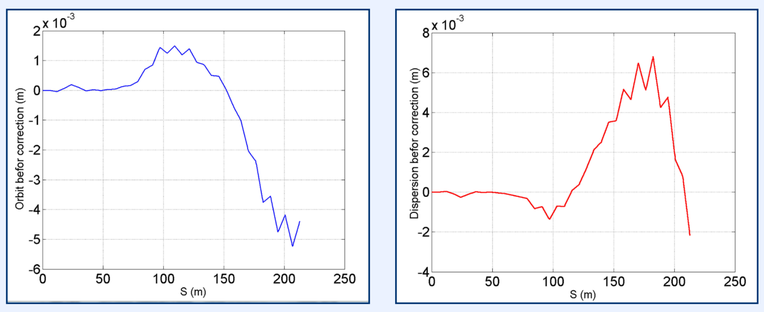


Figure 2: Orbit and dispersion before correction

The beam position at BPMs can be represented by

$$X = R*\theta + \Delta B$$

where R is the orbit response matrix which maps quadrupole offsets θ to the BPM readings downstream.

The task of the orbit correction is to minimizes the relation

$$\left\| R*\theta - X \right\|$$

with respect to quadrupole kicks.

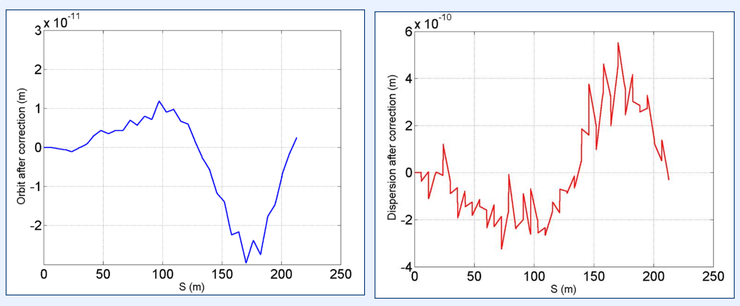


Figure 3: Orbit and dispersion after correction without BPM misalignments

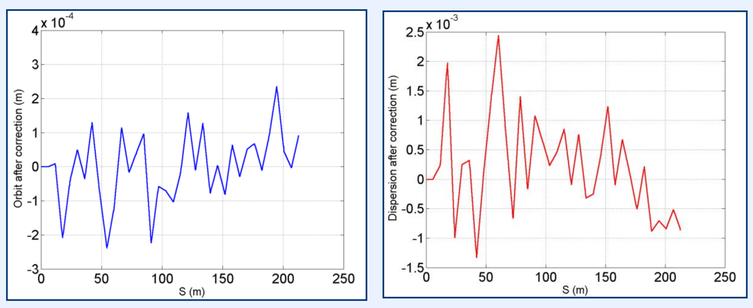


Figure 4: Orbit and dispersion after correction with BPM misalignments

DIFFERENCE ORBIT CORRECTION

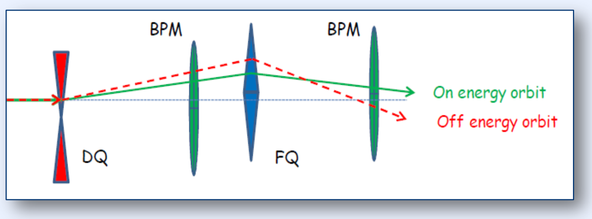
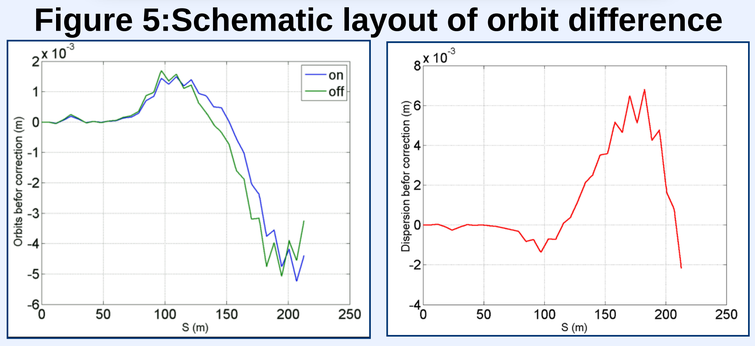


Figure 5:Schematic layout of orbit difference



20% energy difference considered

$$X_{on} = R_{on}*\theta + \Delta B + \sum_{res}^{on}$$

$$X_{off} = R_{off}*\theta + \Delta B + \sum_{res}^{off}$$

Caculate the difference

$$\Delta X = (R_{on} - R_{off})*\theta \qquad \theta = (R_{on} - R_{off})^{-1}*\Delta X$$

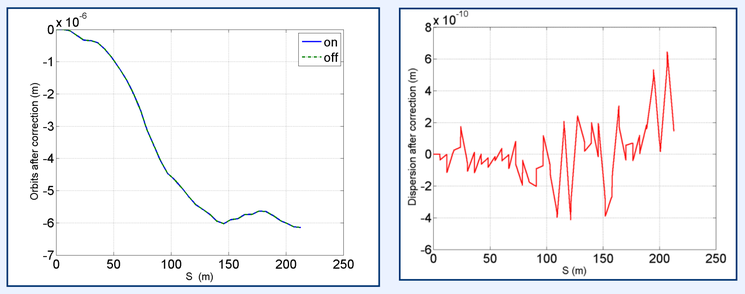


Figure 6: Orbit and dispersion after correction without BPM resolution error

Figure 7: Orbit and dispersion after correction with BPM resolution error

CORRECTION WITH "DISPERSION FREE STEERING" ALGORITHM

The task of the orbit correction is to minimizes the relation

$$\frac{1}{\sigma_{mis}^2}\left\| X - R*\theta \right\|^2 + \frac{1}{\sigma_{res}^2}\left\| \Delta X - \Delta R*\theta \right\|^2$$

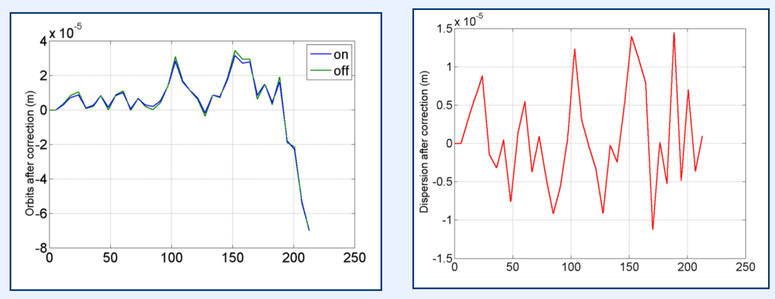


Figure 8: Orbit and dispersion after correction

SUMMARY

Beam orbit and dispersion correction by "one-to-one", "Difference orbit" and "Dispersion Free Steering" algorithms have been performed for European "XFEL" SASE 1 undulator section using ELEGANT and MATLAB.

	ORBIT (mm)	DISPERSION(mm)
One-to-one correction	1-0.1	1-1
Difference orbit correction	1-0.1	1-0.01
Dispersion Free Steering	1-0.01	1-0.01

Table 2: The results

REFERENCES

[1] M. Borland, APS LS-287, 2000.

[2] A. Sargsyan et al, Proc. Of IPAC'14, Dresden, Germany, 2014, pp. 1650-1652.

[3] T. O. Raubeneimer and R. D. Ruth, Nucl.Instrum.Meth. A302 (1991) 191-208

[4] G. Gregorici, "The Singular Value Descomponition and The Pseudoinverse", 2001

ghazaryan@asls.candle.am

http://www.candle.am